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PRELIMINARY INVESTIGATION OF MUNICIPAL AND INDUSTRIAL WATER SUPPLY AND STREAM QUALITY CONTROL REQUIREMENTS ASSOCIATED WITH MULTI-PURPOSE RESERVOIR STUDIES IN THE WILLOW CREEK BASIN, OREGON

Public Health Service
Portland, Oregon

21 December 1961

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WORKING PAPER NO. 33

COLUMBIA RIVER BASIN PROJECT
For Water Supply and Water Quality Management

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December 21, 1961

U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
Water Supply and Pollution Control Program, Pacific Northwest
Region IX, Portland, Oregon

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DATE: December 21, 1961

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General: _____

U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
Water Supply and Pollution Control Program, Pacific Northwest
Region IX, Portland, Oregon

WILLOW CREEK BASIN STUDIES
Feasibility Report

Preliminary Investigation of Municipal and Industrial Water Supply and Stream Quality Control Requirements Associated with Multi-Purpose Reservoir Studies in the Willow Creek Basin, Oregon

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Prepared at the Request of and
in Cooperation with the District Engineer,
U. S. Army Engineer District Walla Walla,
Corps of Engineers, Walla Walla, Washington

U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
Water Supply and Pollution Control Program, Pacific Northwest
Region IX, Portland, Oregon

December 21, 1961

Feasibility Investigation
Municipal and Industrial Water Supply
and
Water Quality Control Studies
Willow Creek Basin, Oregon

INTRODUCTION

This report represents a preliminary examination of present and predicted future municipal and industrial water supply and stream quality control needs in the Willow Creek Basin in connection with studies being conducted by the Corps of Engineers, Walla Walla District, in this basin.

Request for the investigation was made by the U. S. Army Engineer District, Walla Walla, Corps of Engineers, Walla Walla, Washington, by letter dated August 14, 1961, asking for assistance in carrying out provisions set forth in the Water Supply Act of 1958 (Title III, P. L. 500, 85th Congress) for implementation of water supply programs and for stream quality control evaluations applicable to flow regulation provisions as set forth in the Federal Water Pollution Control Act Amendments of 1961 (87-88th Congress).

Studies involve establishment of preliminary estimates on the status, adequacy and limitations of existing water supply sources, waste sources, waste handling practices and stream water quality based on the most recent data available.

Appropriate State agencies, local representatives and available engineering reports were consulted for certain data and viewpoints. Estimates dealing with future water demands, water quality and water quality maintenance needs were aided by use of material contained in the preliminary economic study and estimate of growth report for this region prepared by the Economic Studies Group, Columbia River Basin Project, U. S. Public Health Service.

Materials presented are subject to confirmation pending comprehensive water supply and water quality management studies to be conducted in this region at a later date by the U. S. Public Health Service.

DESCRIPTION

The areas of primary concern lie in the immediate and downstream reaches of Willow Creek below the proposed Heppner Reservoir (see Physical Characteristics of Basin, attached).

The objective of the study is to determine on a preliminary basis whether or not provisions for municipal and industrial water supply and/or low flow augmentation for stream quality control should be considered in the planning of the proposed reservoir.

Studies involve Heppner, Oregon (population 1,660), located immediately below the proposed dam site, and Lexington, Oregon (population 240) and Ione, Oregon (population 350), situated approximately eight miles and seventeen miles downstream from Hoppner, respectively. Each of

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the three communities utilize ground water as a source of supply and the City of Heppner uses the downstream reach of Willow Creek for municipal waste disposal. Domestic wastes at Lexington and Ione are disposed by means of individual subsurface percolation systems.

LEXINGTON AND IONE

Water Supply

The ground water supply at Lexington consists of a 581-foot well, having a yield of 70 gpm or capability of supplying about 400 gallons per capita per day to the community. The supply at Ione consists of a 1,438-foot well with a 300 gpm yield which has never been operated full time.

According to economic forecasts for the Lexington and Ione areas, no significant future increase in municipal and/or industrial water supply is expected. Provision of storage to serve present or future needs at Lexington and Ione, therefore, appears neither needed nor justifiable.

Water Quality Control

In event that at some future time the wastes produced at Lexington and Ione are collected, treated and discharged to Willow Creek, any flow regulation which would provide an increase in the minimum natural flow of the receiving stream would possess value in terms of improved waste assimilative capacity.

HEPPNER

Water Supply

The City of Heppner obtains approximately 510 acre-feet of water annually from underground sources. The City has right to 1.75 cfs of surface flow from Willow Creek; however, this rate of flow frequently and for sustained periods of time is not available (dependable surface supply at Heppner: zero).

Three wells serve the needs of the community. One well (300 gpm) is located three miles above Heppner along Willow Creek and two wells are located about twelve miles above the City near the confluence of North Fork Willow Creek. Each of the latter two wells yield 350 gpm but only when operated separately. Although none of the wells would be inundated by the Project, nearly one mile of transmission line carrying the well water to Heppner is within the proposed impoundment area.

On an annual basis, the developed ground water supply at Heppner (1,090 acre-feet) can satisfy about twice the present demand. During an average day throughout the months of June-August, about 85 percent (0.78 MGD) of the developed yield (0.94 MGD) is pumped. On an average daily peak basis, the developed sources without the community storage reservoir (capacity, 1.11 MG), would not meet the demand (1.1 MG). By utilizing the existing storage with continuous pumping, the system could meet a sustained peak demand for about one week.

According to economic forecasts for the Heppner area, no significant industrial or populati n growth is anticipated.[1/] However, on a per capita daily use basis, significant increases in future demand could be expected.

By the year 1985, the increased per capita demand estimated for Heppner could result in an annual demand for M & I water supply of about 660 acre-feet and, by the year 2010, reach 850 acre-feet. With the existing system, the peak daily demand in 1985 could be sustained only two and one-half days, and in the year 2010 could be sustained only a little more than one day. Also, prior to the year 1985, the average daily June-August demand would utilize essentially the entire developed yield, and by the year 2010 the demand would exceed the yield by about 35 percent.

It is apparent that development of an additional source of water supply will be needed to meet future demands at Heppner. Another well to supplement the existing well supplies would satisfy this need, providing sufficient dependable ground water yields could be maintained or use could be made of stored water in the proposed Heppner Reservoir Project with abandonment of the existing wells.

Although to utilize impounded surface waters for water supply would require expenditures for conventional water treatment, such stored waters would offer greater dependability, gravity advantages and other operational conveniences not possible by the use of underground water.

1/ Preliminary Economic Report and Estimate of Growth, 1960-2010, Willow Creek Area (Oregon), Working Paper No. 6, Economic Studies Group, Water Supply and Pollution Control Program, Pacific Northwest, Public Health Service, Portland, Oregon, March, 1962.

Should construction of the proposed Heppner Reservoir materialize, it would be necessary to relocate the section of transmission line lying within the proposed pool so as to eliminate the possibility of infiltration, impaired maintenance and other possible difficulties. In event that the City of Heppner desires storage space in the proposed reservoir in lieu of development of additional ground water, and inasmuch as costs to relocate the transmission line would be chargeable to the Project, credit in an amount consistent with relocation costs might well be included in a repayment agreement.

Since utilization of Project storage for water supply at Heppner appears entirely feasible, provision for annual withdrawals in amounts shown below should be considered.

Year	Acre-Feet
1960	500
1985	700
2010	900

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Water Quality Control

Associated with municipal and industrial water uses are waste waters and the related effects of such waters on the quality of the waste receiving stream. In addition, in a highly irrigated land area, irrigation return flows which invariably contain leached materials can produce undesirable effects on the stream biota and water quality.

Waste effects and/or effects of irrigation return flows during critically low flow periods can be significantly improved by streamflow regulation during these times.

Waste and land leached waters carry both organic and inorganic materials to the receiving stream. Some of these materials cause a reduction in dissolved oxygen content of the stream through oxidation of unstable materials causing a hazard to fish and other aquatic life while others can create algal and slime nuisances and still others can destroy or interfere with the natural self-purification processes of vital importance in sustaining the purity of the stream.

Wastes collected and treated at Heppner are discharged directly to Willow Creek downstream from the City. Irrigated lands and drainage appurtenances exist along the creek both above and below Heppner. Nuisance odors emanating from the creek below Heppner have at times discouraged the use of stream water for lawn irrigation.

Streamflow requirements for control of quality are, in this instance, based on the effect of residual organic materials contained in treated wastes and land drainage as measured by the extent of dissolved oxygen deficits that would occur in the stream at various rates of streamflow. As it would be desirable to maintain a high standard of quality for recreation, contact activities and other uses, a minimum dissolved oxygen objective of 85 percent of saturation at 25° C. is used. It should be understood that streamflow regulation to control dissolved oxygen at this level would provide substantial control of other quality parameters with the exception of sewage bacteria.

Since economic forecasts for the Heppner and downstream area indicate no significant municipal or industrial growth, the regulation required at the present time is assumed sufficient to maintain control of stream quality to the year 2010.

Following are the estimated minimum flows required in Willow Creek between Heppner and Ione to maintain satisfactory stream quality.

	Willow Creek Minimum Flow Requirements cfs	
Year	May-Oct.	Nov.-April
1960-2010	11.0	8.5

Determination of the above flow requirements allows for a reasonable degree of waste treatment prior to discharge and, therefore, should be regarded as a supplemental quality control measure. It is assumed that sewage bacteria would be controlled at the source by disinfection. The intermediate and winter season flows given above represent an allowance for greater assimilative capacity of the stream as a result of reduced water temperature.

Benefits

The benefit assignable to storage in the proposed Heppner Project for water supply would be equivalent to the long range improvement costs that would be incurred by the City of Heppner in accomplishing similar improvement by the least costly alternative method. For example, the benefit assignable to storage indicated for Heppner could be

derived from selection of the least costly of three likely single-purpose impoundment sites; namely, Shobe Creek, Balm Fork and Willow Creek. Benefits should be based on present construction costs with amortization consistent with current municipal bonding rates.

It should be pointed out that costs to develop ground water sources would not be the equivalent of benefits associated with storage of surface waters. Ground water possesses neither the degree of dependency nor the gravity benefit that surface storage in this instance would provide. It is assumed, however, that surface waters stored in any of the alternate impoundments or the proposed project would require conventional treatment prior to delivery to the consumers.

The benefits assignable to storage or storage releases for quality control may be considered as equivalent to costs involved in providing no less than the required minimum streamflow by means of the least costly of possible single-purpose alternate projects. It is assumed by this that a reasonable degree of waste treatment is applied at the source prior to discharge (minimum flow requirements based on this assumption) and that accomplishment of further quality control to include improvement in land drainage effects can be achieved most cheaply by means of dilution flow.

The benefit assignable to the proposed Heppner Project for quality control, therefore, would be equivalent to the least costly single-purpose project located upstream from Heppner which would provide the amount of regulation previously indicated.

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WILLOW CREEK BASIN STUDIES

Physical Characteristics

U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
Water Supply and Pollution Control Program, Pacific Northwest
Region IX, Portland, Oregon

February 1962

Willow Creek Basin
Physical Characteristics

LOCATION AND SIZE

Willow Creek drains the north side of the Blue Mountains in Morrow County, Oregon, crossing in its lower reaches westward into Gilliam County and flowing into the Columbia at river mile 252 about ten miles upriver from Arlington. Total watershed area is 890 square miles. The basin is roughly cucumber-shaped, about three times as long as it is wide, oriented southeast to northwest.

Willow Creek is about 70 miles long; it becomes a major stream at Heppner, about a third of the distance downstream from the headwaters where it is joined by Balm Fork and Shobe Creek from the south and Hinton Creek from the east. Location of the town of Heppner at the junction of four mountain canyons has made it peculiarly subject to severe flood damages.

In the lower two-thirds of its course, Willow Creek lies close to the northeast side of its watershed. The three major downstream tributaries enter from the south; Clarks Canyon at Lexington about ten miles downstream from Heppner, Rhea Creek about five miles further downstream at river mile 33, and Eightmile Canyon at eight miles above the mouth, as its name implies.

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PHYSIOGRAPHY

Both Willow Creek and its principal tributary, Rhea Creek, rise on the Blue Mountain ridge at elevations well above 5,000 feet. The highest point in the basin is at 6,000 feet elevation, and the confluence of Willow Creek with the Columbia is at elevation 200 feet. Over-all average stream gradient is about 60 feet per mile; 100 feet per mile in the upper third above Heppner and 40 feet per mile on down to the Columbia.

The valleys are narrow, from 100 yards to not more than three-quarters of a mile wide at most. Sideslopes are steep and long. The basin below the mountains is a gradually sloping plateau in appearance, with considerable flat to rolling area on the ridges between the deeply incised canyons. Aspect is northwesterly.

GEOLOGY AND SOILS

At the extreme upper edge of the basin along the top of the Blue Mountain ridge there is a narrow belt of Eocene and other early volcanic rocks. Below, and covering four-fifths of the basin, are Miocene volcanics, principally Columbia basalt. At the lower end in the Eightmile Canyon drainage near the Columbia River are deposits of tertiary continental sediments, primarily tuffaceous, and some areas of quarternary alluvium. Small patches of volcanic ash or other windlaid fine materials overlie the basalts in places.

Soils in the foothill and mountain portions are silt loams to clay loams, usually rather stony. Subsoils on the basalts are clayey and heavy, and have been exposed by erosion on many of the ridges. Valley soils are deeper, looser in texture, and more permeable than the upland soils. Lower ridges--actually dissected bench or plateau--with rolling surfaces have most of the windlaid soil and are used for grain production. Upland ridges and canyons are not cultivated but have been heavily grazed. In both areas, erosion has been severe. Infiltration capacity is low.

COVER VEGETATION

A strip of forest, consisting principally of ponderosa pine, occurs along the crest of the watershed. Patches of true fir and spruce and some lodgepole pine occur in the protected draws on northerly aspects. Only in these forest areas are there any fully developed and undisturbed soils.

Below the forest, extensive areas of brush and grass occupy the ridges and canyons. All of this type has been subjected to long-continued heavy grazing use, and on the ridgetops most of the surface soil has been lost by erosion. "Scab" ridges with only the clayey subsoil showing between the numerous rocks at the surface are common; the cover is sparse and affords little control of runoff.

Small meadows occur in the flatter draws at canyon heads and support a dense grass cover. But often these meadow swales have been partly

covered by material eroded from the scab ridges and have themselves in turn been gullied and dried out.

The lower flat to rolling ridgetops in the dissected plateau region formerly had a grass cover but are for the most part now cultivated for grain. Here, too, erosion losses have been severe, both by wind and water.

In the narrow valleys cultivation has been largely for pasture of hay crops for livestock. Some hardwood trees and shrubs, mainly willows and cottonwoods, occupy fringes of the streambeds. The small towns and the farmsteads all lie in the valleys, usually at canyon junctions where they are particularly subject to flood damage.

CLIMATE

Most of the Willow Creek watershed has an arid climate with hot summers and cold winters. Only the extreme lower end near the mouth has a mild winter climate. Over the lower two-thirds of the basin, the average annual rainfall is less than 12 inches, as low as seven inches near the mouth. Above Heppner the precipitation increases from an annual average of 13 inches to perhaps 30 inches on the crest of the Blue Mountains, and much of this comes as winter snow.

Precipitation records for stations in or near the basin include those for Ella at elevation 830, for Heppner at elevation 1,950, and for California Gulch at elevation 3,220:

Average Monthly Precipitation, inches

Station	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Ella	1.43	0.94	0.64	0.65	0.75	0.62	0.21	0.28	0.41	0.76	1.40	0.95	9.04
Heppner	1.52	1.35	1.29	1.29	1.43	1.08	0.44	0.36	0.96	1.11	1.37	1.40	13.60
Calif. Gulch	1.83	2.52	1.99	2.44	3.51	2.36	0.35	0.55	1.29	1.95	2.45	1.23	22.47

Summer rainfall is low, but winter precipitation is not much greater. Convective storms with high-intensity rainfall are fairly common in summer over one part or another of the watershed. One June storm produced one and one-half inches of rain in 20 minutes, causing a severe flash flood at Heppner. Such storms cover only a limited area and rarely repeat in the same area; however, along the Blue Mountain front, six or eight will occur every year.

Available temperature data indicate a surprisingly warm climate:

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Ella												
Mean Max.	40	44	57	66	75	82	93	88	77	64	52	41
Average	31	36	45	52	59	67	76	72	63	52	42	34
Mean Min.	23	28	32	38	44	52	60	56	47	38	32	27
Heppner												
Mean Max.	40	45	54	61	68	76	85	84	74	63	52	42
Average	32	36	43	48	55	61	69	68	59	51	42	34
Mean Min.	24	28	32	36	41	47	52	52	45	38	33	27

Extremes at Ella are 112 in July, -29 in January; at Heppner, 110 in August, -21 in February. Average length of the frost-free growing season is about 170 days.

Prevailing wind direction is westerly or southwesterly.

Average annual snowfall is 18 inches at Ella, 24 inches at Heppner, and 44 inches at California Gulch. January is the month of greatest snowfall. Snowmelt begins early and is not sufficient to maintain summer streamflow in most years.

Sunshine averages about 60 percent of possible. Humidities are fairly low and evaporation rates high.

HYDROLOGY

Gaging station data for Willow Creek do not amount to much; ten years at Heppner, one year for Rhea Creek and for Willow Creek below Eight-mile Canyon. Records for the Heppner gage are as follows:

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Ann.
Average flow, cfs	3.8	6.5	18.3	22.1	31.5	45.6	58.4	48.4	15.8	2.1	0.2	0.4	22.7

Maximum discharge during the period of record was 812 cfs in May 1957, but the June 1903 flood had a peak estimated at 36,000 cfs. Many days of many years have no flow in August and September.

Six major floods have occurred in the basin in the last eighty years. These have been flash floods, rising rapidly and receding rapidly, with very high peaks but with limited volume. The biggest was the June 1903 flood, but its volume was only 1,600 acre-feet. At the bottom of a canyon below a fan-shaped watershed with three drainages of about the same area converging on its site, Heppner is located in a particularly susceptible situation for extensive flood damage. Watershed conditions

with compacted, almost impermeable soil, sparse cover, and long steep slopes are conducive to rapid runoff and concentration of flow. Much of the flood flow volume is eroded material from the slopes and channel sides, plus debris picked up in the channels.

Annual peak flow is from the spring snowmelt. Summer flow is limited or nonexistent, as all available water is usually diverted for irrigation of some 3,000 acres along the narrow valley. More water is needed as there are about 7,200 acres irrigable in the basin.

Average total runoff at the Heppner gage is about 15,000 acre-feet. For the entire basin, it has been estimated to amount to about 20,000 acre-feet. Annual totals vary from half to double the mean; monthly totals even for the spring period of highest yield vary from one-sixth to three times the mean values, and summer dry period flows vary even more widely.

No information is available on ground water in the basin.

PRELIMINARY ECONOMIC REPORT AND ESTIMATE OF GROWTH, 1960-2010

INTRODUCTION

Purpose of Analysis

This analysis is intended to provide a preliminary estimate of the economic potentials and economic growth of the subject area.

Definition of Area

A major part of Morrow County, Oregon, is drained by Willow Creek. For the purposes of this analysis, the study area includes all of Morrow County except an area in the north-east part of the county which contains the community of Boardman. This area is approximately defined by Census County Divisions as shown in Table II. It is assumed that, although these arbitrary boundaries do not exactly coincide with the sub-basin boundaries, the various discrepancies will be compensating in their net effect, and also that the area as defined constitutes an entity convenient for economic base analysis. Excluded from the projections are the areas on the shores of the Columbia River at the mouth of Willow Creek.

Study Period

The study period is the 50-year period ending in 2010. The year 1980 is taken as an interim point.

Limitations of Analysis

Two limitations apply to this study. The first is that it is intended only as a preliminary estimate of the outlook for the

subject area's growth. Subsequently, in connection with the Columbia River Basin Project for Water Supply and Water Quality Management, an analysis will be made on an industry-by-industry basis of the growth potential in the various sub-basins. At that time, this preliminary estimate will be reviewed, and revised if necessary.

The second limitation is that this study is intended for use particularly in assessing future water needs. Emphasis has been placed on the analysis of those industries which make heavy demands upon the water resource. Other industries have been considered only insofar as they may have a significant effect on future population. For this reason, this study is not submitted as a detailed industrial forecast.

PRESENT ECONOMIC BASE

Locational and Geographic Influences

The study area is located in a sparsely settled rural district. The climate and terrain are suitable for small grain production and cattle production. Although Willow Creek is a tributary of the Columbia River, the navigation and land transportation routes along the Columbia have little influence on the area. The study area is also adjacent to the former bombing range which is now being developed as an industrial park for the so-called space industries.

Land Uses

The area in the Willow Creek Basin is equivalent to 43 percent of the area of Morrow County and is almost entirely within the

county. Land in farms in Morrow County accounts for 84 percent of the county's land. The Willow Creek Basin is almost entirely contained in farms. For the purposes of this analysis, it is assumed that the land uses in the study area are the same in nature as the land in farms of Morrow County and equivalent in amount to 51 percent of the land in farms in Morrow County. Land uses for the study area are described in Table I.

Table I
Estimate of Major Land Uses in Willow Creek Basin
(Source: Derived from 1959 Census of Agriculture for Morrow County, Oregon)

	Acres
Land in farms	565,000
Cropland harvested	92,000
Cropland used for pasture	9,000
Cropland not harvested or pastured	92,000
Cultivated summer fallow	(83,000)
Woodland pastured	48,000
Other pasture	309,000
Irrigated land in farms	7,000

Water Uses

Willow Creek is not used as a water supply at this time except for irrigation. This use is discussed in the section on water quality.

The fish and wildlife uses of Willow Creek have been examined by the U. S. Fish and Wildlife Service. It is understood that only a small amount of recreational fishing now occurs in the stream.

There are no shore uses of the stream involving significant recreational or aesthetic benefits except for the highest

reaches of the stream in the Umatilla National Forest area. A forest park containing recreation facilities is located on the stream inside the national forest.

There is no water-based recreation use of the stream except for its highest reaches.

Population

The study area contained about 4,100 persons in 1960, of which 40 percent were in Heppner City. The distribution of this population is shown in Table II. The population of the county and of Heppner has remained almost unchanged since 1950. It is assumed that the study area population has followed the same trend.

Table II
Population in Willow Creek Area, 1960
(Source: U. S. Census of Population)

	Number of Inhabitants	
	Morrow County	Study Area
Boardman Division	1,145	380[1/]
Boardman City	(153)	
Irrigon City	(232)	
Heppner Division	2,517	2,517
Heppner City	(1,661)	
Ione-Lexington Division	1,209	1,209
Ione City	(350)	
Lexington Town	(240)	
TOTAL	4,871	4,106

1/ Study area portion of Boardman Division was computed by subtracting the population of Boardman and Irrigon cities from the Division and taking half the remainder.

Industry

The distribution of employment in Morrow County for 1950 and 1960 is shown in Table III. The only significantly sized manufacturing operation now in the county is the Kinzua Corporation wood products plant at Heppner with an employment of 80 persons.[2/] The agriculture of the county is primarily based on wheat production. In comparing the employment of the county for 1950 and 1960, it will be noticed that there has been a slight decline in total employment. There was an even greater decline in employment in agriculture, construction, and manufacturing. There was an employment increase in retail trade and other service industries.

Table III
Distribution of Employment in Morrow County, Oregon, in 1950
(Source: U. S. Census of Population, 1950 and 1960)

	1950		1960	
	Number	% of Total	Number	% of Total
Agriculture	815	40.8	635	34.6
Construction	194	9.7	95	5.2
Manufacturing (mainly wood products)	145	7.3	128	7.0
Retail Trade	257	12.9	319	17.4
Other (mainly service industries)	586	29.3	659	35.8
TOTAL	1,997	100.0	1,840	100.0

ESTIMATED GROWTH, 1960-2010

Factors Influencing Future Growth

The pattern of agriculture is not expected to change significantly in this area. The number of farms probably will not increase.

2/ Data are from the "1961 Directory of Oregon Manufacturers", by the Oregon State Department of Planning and Development.

In fact, there was a decline in number of farms in Morrow County of 16 percent in the decade 1950 - 1960. As far as can now be determined, a water control project on Willow Creek would not substantially alter the number of farms in the study area.

Other industrial developments in the study area are also not expected to change significantly. It is assumed that the industrial facilities proposed for the Boardman area, which is outside the study area, will have no direct effect on the study area. These facilities which the Boeing organization is considered likely to construct will probably immediately increase the population of the Boardman area by several hundred persons. The ultimate growth of the Boardman area, however, might be several times as great; and this could increase recreational needs in the vicinity.

Future Population

Based on developments which can now be anticipated, no change in population is forecast for the study area.

Future Land Uses

The only significant change in land use which can be anticipated is an increased amount of irrigation which would occur if a water control project is built on Willow Creek. There would also be the withdrawal of some land because of the reservoir which such a project would require.

Future Water Uses

Changes in water uses will depend upon the construction of a water control project. Such a project would make possible additional irrigation. In addition, if water quality was improved and a reservoir was made available, the stream would support certain types of water-based recreational activities.

It is understood that the U. S. Fish and Wildlife Service has forecast a considerable increase in the use of the stream (particularly the reservoir area) for recreational fishing with the construction of conservation pools. The reservoir area would also provide an opportunity for such water-based activities as boating and swimming. Based on the attendance records of other reservoirs in the area, the annual recreational attendance would be numbered in the thousands. Demand for recreation will increase even if population remains the same if historic trends of increasing leisure continue. The construction of the industrial facilities in the Boardman area also can be expected to increase the demand for water-based recreational facilities in the study area.